orestry Research West

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Agriculture

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

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In This Issue

Cover

Scientists at the Pacific Southwest Station are working to find better ways of managing destructive forest insects without harming other beneficial organisms. To help with these studies, Biological Technician Lucille Boelter supervises the rearing of a laboratory colony of western spruce budworms. The cups contain larvae and cubes of artificial diet. Read more about it on page 1 .
(Photo by Dennis Galloway)

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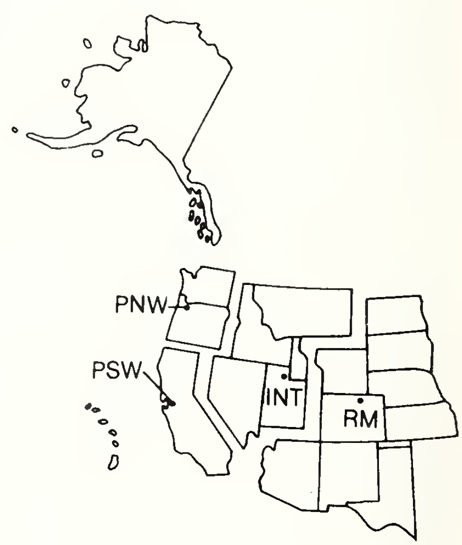
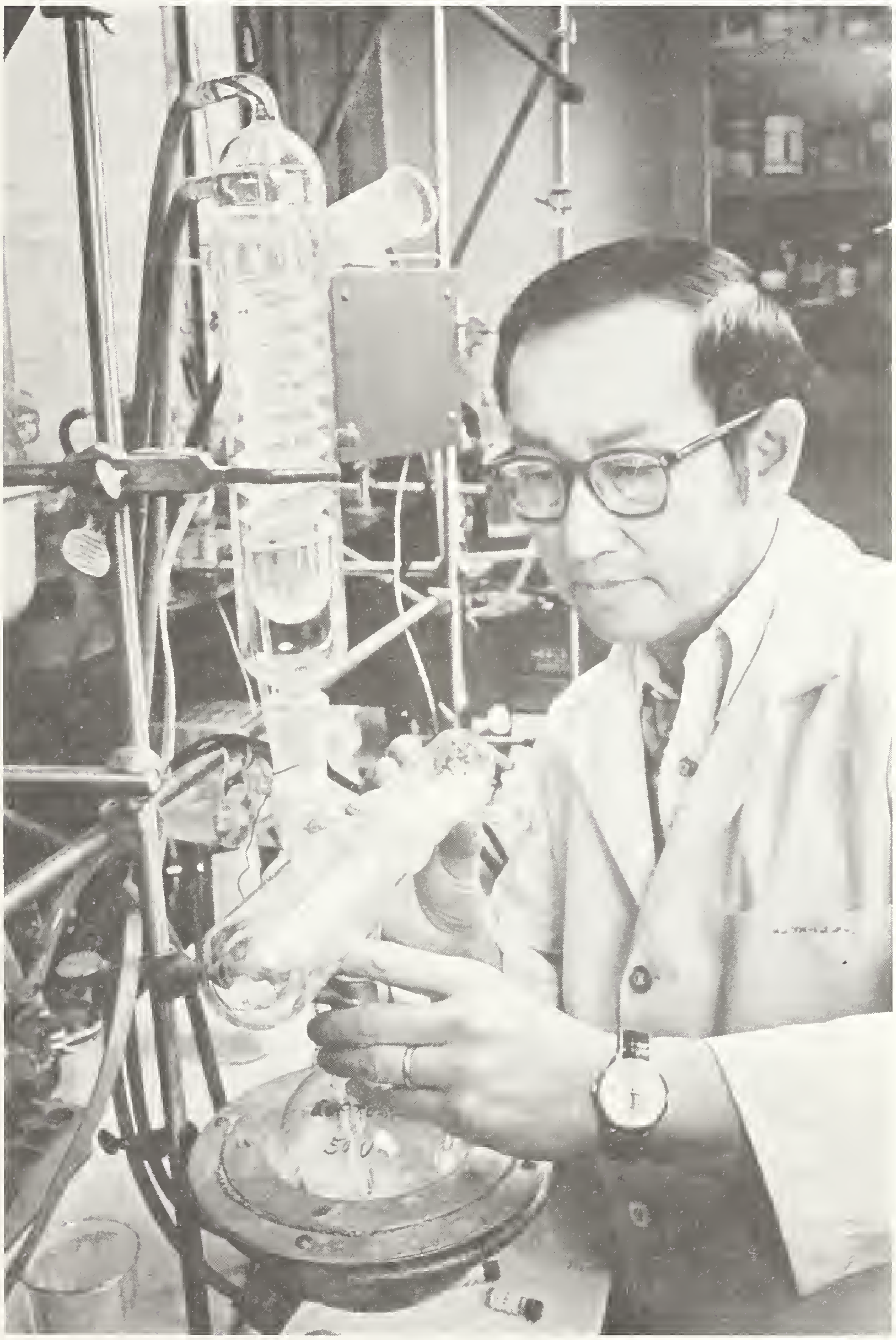


Researchers evaluate insecticides

by Marcia Wood
Pacific Southwest Station

Chemical insecticides that are used in forests should control destructive insects without harming other forest life. This is the standard that researchers in the Pacific Southwest Station's Insecticide Evaluation Project follow in assessing insecticides that are proposed for use in forests. According to Research Entomologist Michael I. Haverty, who is leader of the Insecticide Evaluation Project, scientists on this team are "primarily concerned with determining the very least amounts of a prospective insecticide that can be used—with good results—in the forest."



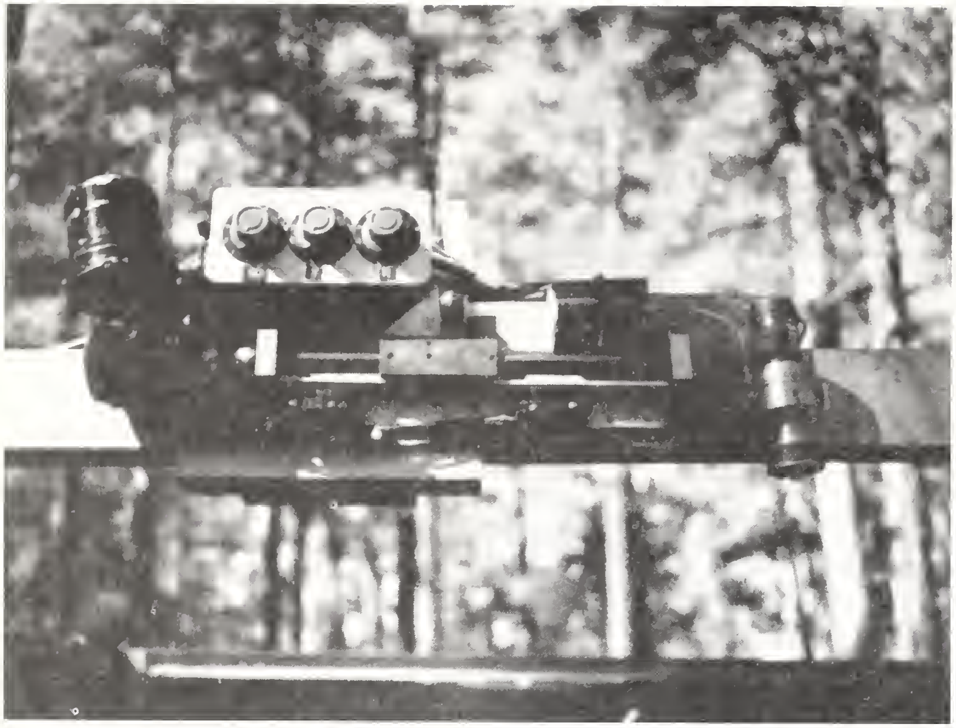
"This approach represents a major shift in attitude and techniques for controlling insects," Haverty says. "In the past, the only concern was, "Did you kill the pest?" In many cases, there was little or no concern for the fate of other organisms. Now, however, the approach is to determine what can be done to manage destructive insects without damaging beneficial predators or parasites, or other forest organisms."

Project scientists, who are stationed in Berkeley, California, are currently working in three different areas of research. They are evaluating candidate insecticides, to determine how effective these materials are in controlling defoliators—foliage-eating insects such as the western spruce budworm, Douglas-fir tussock moth, and larch casebearer. The team is experimenting with ways to control regeneration insects—pests that attack seeds, cones, young seedlings, and plantations. Finally, the researchers are developing techniques to prevent bark beetles from successfully attacking individual, high-value conifers, such as those in campgrounds and other recreation areas, seed orchards, research plots, greenbelts, or similar sites.

Target: defoliators

Over the past several years, the Insecticide Evaluation team has screened hundreds of insecticides, rating them for their potential effectiveness in killing major defoliators. These laboratory bioassays typically determined what doses were lethal to a specific percentage of the target pest population. A sister research team, the Field Evaluation of Chemical Insecticides Research Unit in Davis, California, used the data in deciding which of the chemicals and dosage rates to select for further testing in the field.

Research Chemist Mel Look says that analyzing tree bark and needles for insecticide residue is "like looking for a needle in a haystack—we have lots of substrate, containing only minute amounts of insecticide." (Photo by Dennis Galloway)



The spinning porous sleeve nozzle (far right) on the aerial application simulator produces the same size droplets as nozzles used in many aerial spray operations. This and other features mean that the simulator can be used to replicate—on a small scale—many of the conditions that exist in an actual spray operation.

The field tests are both time-consuming and expensive: a test of two chemicals applied at three different dosages in an aerial spray operation, for example, can cost between $50,000 and $100,000. The goal of the field tests is to kill 90 percent or more of the insect population. Project Leader Haverty says that in the past, making the jump from dosages tested in the laboratory to the 90-percent-or-better control level in the field had been "almost pure guesswork," with the result that sometimes dosages based on laboratory findings weren't effective in the field tests. For this reason, the Insecticide Evaluation Project has made major changes in its bioassay procedures. First, the team is now determining the quantities of a "candidate" insecticide that are needed to kill 90 percent of the pest population. Second, the Berkeley group is changing the way that insecticides are applied in the laboratory. Before, insects were treated with either a drop of insecticide (applied directly on the insect's body) or with a spray mist. After treatment, the insects were allowed to feed on an artificial diet. Now, the insects are sprayed as they feed on their natural diet of tree foliage. Because they have at least 24 hours before spraying to acclimate themselves to the foliage, the insects have adequate time to build a feeding shelter—just as they would under natural conditions. The third change in procedure concerns the nozzle used in applying the insecticide. The new nozzle is a miniaturized version of the kind that is commonly used in helicopter spraying. "In making these changes, we are trying to get a better simulation of field conditions," Haverty explains. "There are still some factors we aren't able to account for, such as the movement of spray away from the target (drift), breakdown of the insecticide in the sunlight (photodegradation), and the coalescence and evaporation that occur when small droplets fall to the ground from a helicopter that is moving at 60 miles per hour. But, we hope that the changes that we are experimenting with will bridge the gap between laboratory tests and large-scale field tests."

Aerial simulator

In a similar move to close this gap, Research Biologist Chuck Richmond and Instrument Maker Emanuel Moellman have designed an "aerial application simulator"—a device that can be moved about in the field and used to individually spray small trees. Trees that are from 3-to-12-feet high, and already have a natural infestation of a target pest, are used in these experiments. The simulator consists of an 8-by-8-foot lightweight metal frame that adjusts to heights of from 6 to 12 feet. The frame supports a motor-driven, battery-powered insecticide applicator that is equipped with a porous sleeve nozzle. The nozzle produces droplets that are about the same size as those formed in helicopter tests. Nylon tarps extend from the metal frame to prevent the insecticide from drifting to surrounding trees.

"We constructed the simulator so that it gives us the same pattern of large and small droplets that are characteristic of an aerial spray operation," Richmond says. Small white cards made of glossy paper are placed around the base of test trees, to catch the spray droplets. A pink or red dye in the spray makes it possible to later analyze these cards and determine two key characteristics of the spray pattern—the number of drops per square centimeter and the average diameter of the droplets. Adjustments are made in the aerial simulator until the pattern on the cards comes as close as possible to the actual spray patterns made on cards from previous helicopter tests. Quantities used successfully in tests with the simulator convert easily into the standard gallons-per-acre measure needed for the aerial tests.

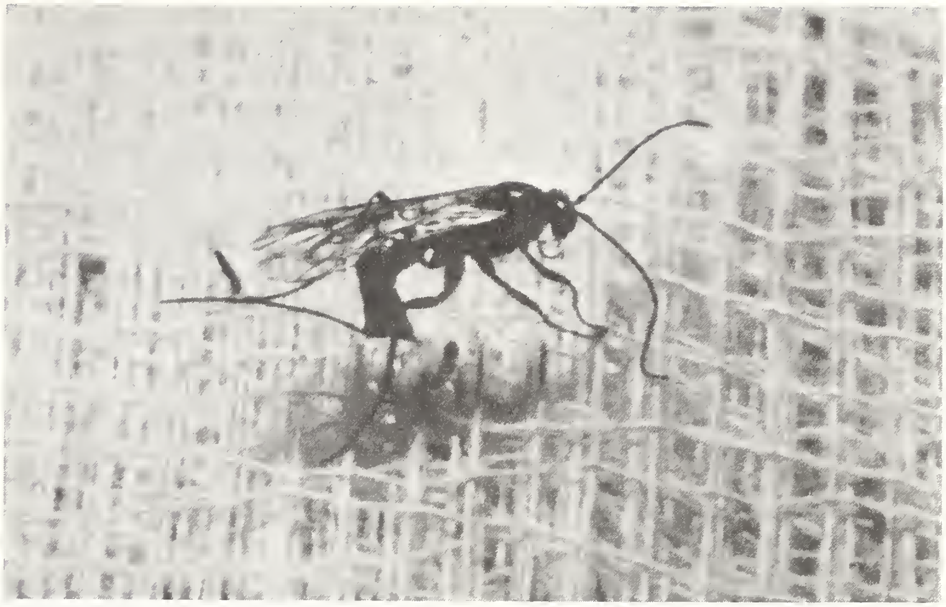
Rearing colonies

In the aerial simulator experiments, researchers can use natural populations of target pests. The laboratory bioassays, however, require either importing or raising large quantities of insects. Research Entomologist Jackie Robertson has developed new and successful techniques for rearing laboratory colonies of two target pests—the western spruce budworm and the Douglas-fir tussock moth.

Her research involved making countless modifications in the artificial diet required for these insects, and numerous experiments to determine the proper breeding, feeding, and rearing conditions. Using Robertson's guidelines, the Unit can now produce a continuous supply of the thousands of healthy, early maturing western spruce budworm and Douglas-fir tussock moth that are needed each week for bioassays.

Robertson is also involved in two other areas of research. One is the development of computer programs that can quickly analyze laboratory data about response of the budworm, tussock moth, and other insects to various doses of insecticides. The POLO-1 and POLO-2 (Probit or Logit Analysis) programs that she and colleagues from the Experiment Station and from Cambridge University have developed are statistically sound, easy to use, and more informative than any other computer programs currently available for these types of analyses.

In a second area of research, Robertson and colleague Molly Stock of the Department of Forest Resources at the University of Idaho, Moscow, have studied western spruce budworm to determine if genetic differences among budworm populations may correspond with natural immunity, or resistance, to certain chemicals. "If a population has a natural, genetically controlled immunity to an insecticide, applying the material would make the situation much worse," Robertson explains. "The budworms that survive the spraying will be those that are the most resistant; by spraying, the population would be pushed toward even greater resistance." Stock and Robertson have tentatively identified at least one budworm population that seems to have a strong resistance to a commonly used insecticide. They hope to determine if there is a genetic marker, such as one of the esterase enzymes, that would be a reliable indicator of resistance.



The parasitic wasp Glypta fumiferanae injects its eggs into a young western spruce budworm.

Parasitized budworms

In other studies of defoliators, Research Biologist Marion Page is determining how parasitism affects the response of western spruce budworms to insecticides. The parasitic wasps *Glypta fumiferanae* and *Apanteles fumiferanae* are being used in these experiments.

A previous study by Research Entomologist Carroll Williams of the Station's Integrated Pest Management Unit, and colleagues, suggested that the ratio of parasitized to nonparasitized budworms was higher after the insects had been sprayed. "Parasitized budworms may be less mobile and may have less chance of coming in contact with the spray," Page explains. His purpose in learning more about this phenomenon is to determine if—through elimination of nonparasitized budworms—spraying gives parasites a better chance to reduce the remaining budworm population. "We may find that spraying will knock the budworm population down to a point where the parasites can take over. If this turns out to be the case, it would mean that we were one step closer to achieving control of the pest population through natural means. This is the goal of integrated pest management."

Page and colleague Nancy Rappaport, also of the Insecticide Evaluation Project, are the first to raise an on-going laboratory population of *Glypta*. For their studies, *Glypta* females will be allowed to parasitize some budworms from the laboratory colony. Then, Page will monitor the response of the parasitized budworms to application of several insecticides, including mexacarbate and carbaryl. Similar experiments with *Apanteles* will follow.

Regeneration insects

Among the regeneration insects that the researchers are studying is the mountain pine cone beetle, a pest that has repeatedly destroyed much of the cone crop produced in the Forest Service's western white pine seed orchard in Sandpoint, Idaho. The Berkeley Unit is helping the Field Evaluation Unit develop a pest management strategy that can be used to protect future cone crops from the pine beetle. The study will provide guidelines for estimating the size of each year's beetle population, and for predicting the exact date when beetles will emerge from overwintering. According to Research Entomologist Pat Shea, who is leader of the Davis team, this information is needed to properly schedule the spray operation. "Timing is critical," Shea says. "The cone beetle can attack the conductive tissue in a pine cone—and effectively kill the cone—in less than a hour. And, the beetle usually begins its attack less than 24 hours after it emerges from overwintering."

The Sandpoint work so far has indicated that the trees must be sprayed with insecticide just before the beetles emerge for flight in early spring. Shea and Haverty hope to be able to pinpoint the emergence date in "degree days"—a cumulative measure of temperatures that occur as winter turns to spring and the insects prepare to emerge. The insecticide used in the seed orchard test this past spring was permethrin, a material that Haverty describes as "safe and fast-acting."

In another study of regeneration insects, Research Entomologist Rene, Pieper and University of California at Berkeley Researcher W. Jan Volney of the Division of Entomology and Parasitology are analyzing the insect pests of a Douglas-fir seed orchard in the foothills of the west-side Sierra Nevada in central California. Pieper and Volney have monitored the number, position, and condition of flowers (and later, cones) of Douglas-fir from different sources and clones, and have dissected and analyzed some of these cones in the laboratory. The purpose of their study is to develop methods to predict, detect, and monitor insect damage to cones and seed crops.

Protecting ponderosa

The Project's newest area of research concerns techniques for individually treating high-value ponderosa pine with insecticides, to protect them from bark beetles. In cooperation with the Davis team, Project Leader Haverty is monitoring the effectiveness of applying the insecticide carbaryl in the fall months. He will compare these findings with the results of a previous study, in which carbaryl was applied in the spring. The advantage of the fall applications would be that fewer forest visitors would be staying at campsites or cabins, or visiting Ranger Stations, at that time.

Carefully measured doses of an insecticide were added to the mold of artificial diet. The smaller budworms are those that have shrivelled and died. (Photo by Dennis Galloway)

In another experiment, Haverty and the Davis team are determining whether any environmental contamination or risk to the person applying insecticide results when either a pump tank with a hose or a large hydraulic sprayer is used. "Drift, splash, and "misses" are the types of contamination that concern us," Haverty says.

Residue analysis

The contamination study will include a procedure known as residue analysis. Samples of tree foliage and bark, along with other vegetation, and soil, are used in these analyses to determine how much insecticide actually reaches the intended target, how long the insecticide persists in the environment, and how far it drifts. Residue analysis is a specialty of Research Chemist Mel Look, who says that most of the more widely used techniques are designed for analyzing insecticide residues on agricultural crops. "These techniques don't really meet our needs in forestry," Look says. "For one thing, the substrates are different—we need to analyze residues on grasses, the litter layer, or conifer foliage, not on a cotton plant. Also, we are working with submicrogram quantities of insecticides: most conventional residue analysis techniques are designed for working with much larger amounts of chemicals."

Look is currently experimenting with different approaches that might shorten the lengthy and time-consuming procedure that is known as "clean up"—extracting or separating the insecticide residue from the waxes, resins, and other substances that are contained in foliage and bark samples. One method he is trying is exclusion liquid chromatography, in which the field sample of bark, foliage, or other material, is ground up into find particles, extracted with solvents, and passed through a glass column. The spaces between the molecules of organic material in the column serve as a filter, and segregate the incoming molecules according to their size. This size-sorting separates the insecticide from the other materials. A gas or liquid chromatograph is then used to determine how much insecticide was in the sampled area.

Another technique that Look is testing is called differential absorption. With it, the ground-up field samples and solvent are separated according to their positive or negative charge.

The residue analysis guidelines that Look develops will be used by the other researchers in the Project as part of their aerial simulation tests, bark beetle tests, or other studies. This interrelatedness is typical of the research team: each scientist is working in a highly specialized area of study, but all of the areas are closely related. And, although the methods and materials used in the Project's more than 20 different studies may differ, the goal of each of the studies is the same—to provide safer, more effective ways to manage destructive forest insects.

A bibliography of reports and technical articles that Insecticide Evaluation Project scientists have published recently is available to *Forestry Research West* readers. To request a copy, write: Dr. Michael I. Haverty, Insecticide Evaluation Project, PSW Station, P.O. Box 245, Berkeley, California 94701.

"This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state and/or Federal agencies before they can be recommended."

Old-growth forests

by Samuel T. Frear
Pacific Northwest Station

Each old growth Douglas fir is shaped over centuries of time by a host of factors to make them highly individualistic.

The first glimpse of old-growth Douglas-fir forests blanketing the mountain slopes of the Pacific Northwest can be awe-inspiring. The immensity of the trees, the number of them, and the intensity of their shade are among the elements that reinforce the first impression: these are very special trees.

And the old-growth coniferous forests of Northern California, Oregon, Washington, and British Columbia are very special. They are virtually unique on the globe: Only in limited places elsewhere on earth are the conditions present to permit such forests.

These forests, of which the Douglas-fir is the most prominent member, can have trees that tower up to 300 feet with a diameter of 10 feet or more. Trees continue growing for many centuries, sometimes to an age of 1,000 years, with a biomass per acre higher than most other species. The massiveness of the tree, along with its extreme longevity, is distinctive. These trees affect the atmosphere, and a first-time visitor notices the coolness of the air beneath their canopy in summer, and its warmth during winter.

Knowing these things, standing in the midst of an old-growth stand, repeatedly brings out wonder. A young forester from the East stood beneath a towering Douglas-fir for the first time and said in amazement, "Look at all that energy."

Yet, as we more and more appreciate these old-growth trees, we become increasingly aware of how little we know about them. What roles do the live trees and the dead trees play in the ecosystem? How do they affect streams and rivers? In what ways do wildlife need them? How do they fit into the web of life that interconnects all living things? What characteristics do the trees have that must be perpetuated?

These questions are relevant as we begin to realize that the world's resources are finite. It is important to raise these questions while there still are thousands of acres of old-growth stands remaining in the Pacific Northwest.

To set a framework for discussion of old-growth forests, a group of scientists at the Pacific Northwest Forest and Range Experiment Station's Forestry Sciences Laboratory and Oregon State University in Corvallis, Oregon, have compiled a summary of research about all aspects of the old-growth forests as a background for discussion of future research needs and proposed forest management practices. They suggest policies that forest managers can implement to protect old-growth values within various land allocations or timber management plans.

Jerry Franklin, a research forester and project leader in Corvallis, says there were several reasons for compiling information about the old-growth forests of the Pacific Northwest. First, he believes the information will be useful to land managers. Secondly, it was interesting to put together all the studies of old-growth "just to see what we did know." Thirdly, the public has become interested in old-growth timber.

Outstanding characteristics

To set the stage for discussion of the structure and function of old-growth forests and the management strategies necessary to protect them, it is first important to understand just how unique they are.

The biomass of old-growth forests is astounding. The Pacific Northwest forests contain one of the largest biomass accumulations in the world. Theories about forest growth have been shattered as more is learned about them. There just is no comparison to other forests in temperate areas. The above ground biomass for Douglas fir/western hemlock aged 250 to 1,000 years averages 345.7 tons per acre, compared to 96.8 tons per acre for mature temperate deciduous forests and 126.7 tons per acre for mature tropical rain forests.

In terms of productivity, the advantage the Pacific Northwest old-growth trees have is their sustained height growth and longevity. They continue to grow substantially in diameter and height for decades after trees in other temperate regions have reached equilibrium.

Still another outstanding feature of Pacific Northwest forests is the dominance of evergreen coniferous trees. A unique phenomenon is that there are ratios of 1,000 evergreens to one hardwood in old-growth forests, different from most temperate regions of the world where deciduous hardwoods or a mixture of hardwoods and conifers are dominant. There has been much speculation about the reasons for the evergreen dominance in the Pacific Northwest, but climate appears to be the critical factor, Franklin believes.

Evergreen coniferous trees are well adapted to the unusual climate of the Pacific Northwest—wet, mild winters and warm, relatively dry summers. Deciduous hardwood species, on the other hand, have considerable disadvantages competing with conifers in this climate. The conifers, in contrast to hardwood, can utilize the dormant season for photosynthesis; they are not dependent on assimilation during the growing seasons, a time when photosynthesis is frequently constrained by the dry summers. Thirdly, conifers have lower nutrient requirements and need not get this from the soil at a time when decomposition and nutrient release are at a minimal level due to reduced soil moisture. Dominançe by evergreen conifers appears to be an evolutionary response to peculiarities of the Pacific Northwest climate.

Still another unique aspect of the old-growth forest is the massive size of trees. Although more research is needed to determine what advantage this has, it seems obvious that large size and longevity have adaptive advantages. They allow a species to overtop species of smaller structure, or to outlive species of short life span, or both. Long lived species can span long periods—sometime centuries—between natural destructive episodes. And the large size allows buffering against all the slings and arrows the environment throws up to affect adversely all but the strongest, the biggest, and the best.

In view of all these unique qualities, Franklin is amazed that there is lack of quantitative data on various aspects of forest succession in the Pacific Northwest. Although these forests have been observed for a hundred years or more, most analyses are either anecdotal, or based on inference drawn from tables and charts.

But the times are changing.

Large logs may take several centuries to decay, serving as a complex, meticulous source of energy and nutrients.

Structural components of old-growth forest

Franklin looks at the old-growth forests in terms of its four structural components: large, live trees; large snags; large logs on land; and large logs in streams. What characteristics in each of these components should be perpetuated or re-created, and why?

It is these structural components that are, in large measure, unique to an old-growth forest ecosystem, setting it apart from young growth and managed stands. Most of the unique or distinctive features of old-growth forests can be related in terms of flora and fauna (thus, how it is composed) and the way in which energy and nutrients are cycled (the forest's functions). The tree plays a progression of roles for the time it is alive through its transformation to an unrecognizable component of the forest floor.

Living trees

Old-growth trees are highly individualistic; ages of trees vary considerably, and a stand is much less uniform than are 50- to 150-year-old stands. Each old-growth tree has been shaped over the centuries by its genetic heritage, site conditions, competition with nearby trees, and the effects of storms, diseases, insects, and soil movement. These old trees have important ecological roles:

1. They are the habitat for distinctive epiphytic plants (plants that live on other plants, such as moss and lichens). More than 100 species of moss and lichen function this way. When moist, the canopy is an important climatic buffer, capable of holding 264,000 gallons per acre. This is important for the survival of lichen *Lobaria oregana*, an important fixer of nitrogen in the environment.

2. They have important effects on carbon, nutrient, and water cycling. A single old-growth tree can have more than 60 million needles weighing 440 pounds with a surface area of 30,000 square feet. The tree is a large photosynthetic factory.

3. It is the source for other key structural components of the ecosystem: standing dead trees, logs on land, and logs in streams.

These trees also serve as the habitat for invertebrates. A single stand may have more than 1,500 species. Researchers found that only a minority of these spend their entire life in the canopy. The majority are adults which have spent their immature stages on the forest floor or in streams.

Standing dead trees (snags)

Large standing snags in excess of 20 inches dbh and 65 feet in height are most valuable in an old-growth stand, particularly as a habitat for a variety of vertebrate and invertebrate animals, birds and insects. Snags usually last for 50 to 75 years in natural stands before they deteriorate to stubs less than 35 feet which are of little value as habitat for fauna. Franklin reports that this aspect of old-growth forests needs more study. New research is underway, however, that is expected to generate useful information.

Large logs on land

There typically are 38-85 tons of logs per acre in old-growth forests. They are an important source of nutrients such as nitrogen and potassium. Large logs disappear much more slowly than standing snags. It is estimated that it requires 480 to 580 years for a 30-inch dbh Douglas-fir to become 90 percent decayed.

During this time these logs are a haven for many hundreds of insects. Reporting on these in a March 1981 issue of Natural History, author Mark Deyrup reported: "There is a new vision of the deadwood in forest and woodlot, deadwood that is no longer the very symbol of unproductivity, but rather a complex, meticulous recycling station that deposits minerals and humus on the ground, while pouring forth the stored energy of the tree in a swarm of organisms indispensable to forest food chains."

Franklin agrees: "The most important function of logs are as sinks and storage compartments for energy and nutrients and as sites for nitrogen fixation." Documenting the importance of these logs, he said, is some of the most significant research conducted about old-growth groves in recent years. "We just didn't know as much as we should have about the woody debris on the forest floor," he stated.

Logs in streams

Logs are at least as important, and possibly more so, to the stream component of the old-growth ecosystem as they are to the terrestrial component. The logs are a dominant element in streams for distributing aquatic habitats, providing stability of streambeds and streambanks, and in routing sediments and water. Large debris remains in water for a long time, commonly from 25 to more than 100 years.

In smaller streams, logs cause the energy of streams to be dissipated at falls and cascades, causing less erosion. There is more sediment storage in channels, slower routing of organic detritus, and greater diversity of habitat. Large debris may be the principle factor determining the characteristics of aquatic habitats for fish and for microbial, invertebrate, and vertebrate organisms. The woody debris itself is a major source of energy and nutrients for the stream system.

These, then, are the structure and function of the four components of an old-growth forest. Researchers are convinced that they are of overwhelming importance, performing roles without which a forest ecosystem would not survive. How, then, can land managers protect, enhance, and perpetuate the functions of an old-growth forest? The key is tying management decisions to the four components, Franklin believes.

Management alternatives

Franklin says there are three alternatives:

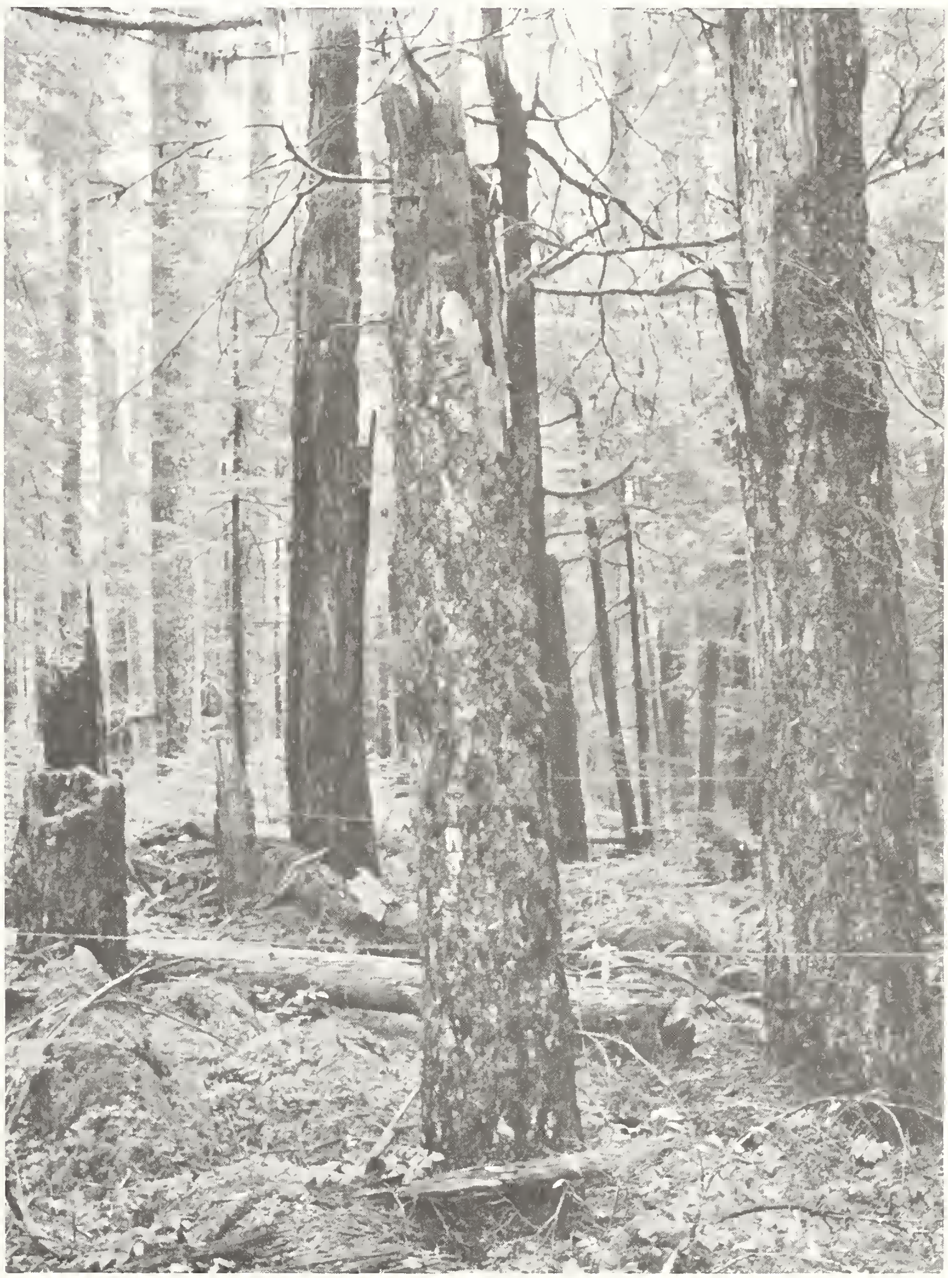
(1) Perpetuate existing old-growth stands. This is the surest course of action since old-growth conditions can persist for several centuries.

(2) Re-create ecosystems with old-growth characteristics using long rotation periods between harvesting.

(3) Provide for individual old-growth features in any timber management plan. This involves applying practices to the main body of commercial forest land. Some of the most important ecological features of old growth can be duplicated with relatively small impact to timber production.

If forest managers decide to implement either of these alternatives, they will have to decide how the old-growth allocation should be distributed, which management practices should be followed in areas selected for retention and for long rotations, and the size and shape of old-growth areas.

The ecologically most desirable management unit is an entire drainage basin, preferably of from 300 to 500 acres, Franklin believes. These have natural topographic boundaries providing protection to the stand, and natural land-water interaction allowing inputs of wood debris to continue. Plant and animal diversity will be higher.



Large standing snags last from 50 to 75 years, and are habitats for a variety of wildlife.

Protecting old growth along streams is also a workable alternative. The trees not only shade and minimize water temperature increases, but also provide energy to the stream, and debris to create dams. These streamside areas also can provide migration routes for organisms that need mature forests. Streamside old-growth stands, too, can provide continuity to the forest, and will avoid the loss of species in "islands" of habitat.

Success in managing forests for old-growth characteristics will depend on learning to manage the dead, organic material as imaginatively as live trees. Decaying snags and logs, particularly in streams, are more beneficial than previously thought. Franklin hopes they no longer will be viewed solely as waste, a fire hazard, or impediments to management.

When managing for old-growth characteristics, the forester can provide for retention of large snags and logs. These are much more than habitats for vertebrate animals. Their value for cycling and conserving nutrients, especially nitrogen, is important—a fact that 10 years ago was not known. It appears, Franklin says, that at least several large logs per acre should be left following timber harvesting. But more research is needed.

Logs in streams are a dominant element for distributing aquatic habitats, providing stability, and in routing sediments and water.

The retention of small groups or individual old-growth trees may also be useful as a technique for providing a source of epiphytes to adjacent young trees. Also, in the long run, this old growth will provide the forest with a source of snags and logs.

Franklin is convinced that research on old-growth trees is just getting started. Now that numerous studies are underway or planned for the future, he anticipates that our understanding of the ecological function of these trees will increase immeasurably. This, in turn, will provide additional insight for forest managers to plan for this forest resource in conjunction with other resources. Then, too, the term "decadent" tree will disappear from our vocabulary as we better understand that at every stage of its existence a tree performs vital environmental functions.

For further reading

The following publications are available from the Pacific Northwest Station:

Franklin, Jerry F.; Cromack, Kermit; Denison, William; and others. *Ecological Characteristics Of Old-Growth Douglas-Fir Forests.* USDA Forest Service General Technical Report PNW-118. Portland, Ore., Pacific Northwest Forest and Range Experiment Station. 1981.

Franklin, Jerry F. and Waring, Richard H. *Distinctive Features Of the Northwestern Forest: Development, Structure, and Function. In* Proceedings of 40th Annual Biology Colloquim: 59-86, Corvallis, Ore; Oregon State Univ.; 1979.

Learning to manage southwestern riparian ecosystems

by Matthew McKinney
Rocky Mountain Station

Rare, oasis-like riparian zones, fed by surface and subsurface water, provide a welcome contrast in semi-arid New Mexico and Arizona. Often supporting more diverse plant and animal communities than surrounding ecosystems, riparian zones play a unique and valuable role in Southwestern ecology — extending from the arid desert floor to cool mountain meadows.

According to Robert Szaro, riparian specialist with the Rocky Mountain Station's Forestry Sciences Laboratory in Tempe, Arizona, "Conflicts between wildlife and human populations make preserving and managing riparian zones of increasing concern to land managers, property owners, and others." Forest Service scientists, cooperating with several state and federal agencies, are working to find better ways of managing riparian ecosystems while minimizing conflicts.

Because the Southwest is one of the fastest growing regions in the U.S., natural resources are in high demand. And people are attracted to riparian zones which offer not only livestock grazing, timber products, agriculture opportunities, recreation, and homebuilding sites, but also shade, water, lush vegetation, and diverse wildlife species.

Wildlife, like people, are also drawn to these wet and wooded areas for feeding, resting, and drinking. Wildlife use riparian zones because of their increased floral diversity and density relative to upland vegetation; a large amount of edge (i.e., the interface between two different plant and animal associations); loose, deep soil in which to burrow, tree cavities for nesting and perching; and often times abundant food and water. Many species use riparian areas throughout the year as breeding sites, wintering areas, and as migratory corridors.

Southwestern riparian zones are also home to several threatened and endangered wildlife species. The bald eagle is one, depending on the riparian ecosystem for its primary food source, fish. The Gila trout and Arizona trout, both native to the Southwest, are threatened because of competition with more popular, introduced sport fishes.

Although Southwestern riparian zones are typically long and narrow, winding through the arid countryside, various land use practices have created "riparian islands" — i.e. areas isolated from larger riparian zones and concentrated around localized water sources such as springs and wells. Consequently, wildlife and their habitats are adversely affected by these human activities through stream and river diversions, soil compaction and runoff, trampling and clearing vegetation, collecting firewood, ground water pumping, and so on.

Southwestern riparian vegetation changes with elevation. Here, a cottonwood-willow association meanders through the arid countryside along the floodplain.

Several birds, like this Harris Hawk, and other wildlife depend on riparian ecosystems for feeding, breeding, nesting, and resting sites.

Szaro believes, "Land managers need better guidelines to stop the rate of vegetation loss and insure the replacement of this vital ecosystem. Our primary objective should be to maintain a healthy ecological system where species can reproduce naturally. However, the variety of plant-animal associations in Southwestern riparian zones make it difficult to develop generalized management practices."

But Szaro, along with many other scientists, are identifying and recording tree and perennial plant species for all elevation gradients of the riparian zone in Arizona and New Mexico. Once this is done, a classification system will be developed to aid land managers in determining the tradeoffs involved when riparian areas are designated for various uses — wildlife habitat, livestock grazing, agriculture, timber products, recreation, homebuilding, and so on. At the same time, scientists will identify which wildlife species depend on which plant communities for food and cover, thereby letting land managers know which species will be affected - and taken into account - by his/her decisions. Computer programs, including RUN WILD and ECOSIM, are helping scientists identify food and cover requirements for many species, and in developing management guidelines for Southwestern riparian ecosystems.

Management implications so far

Research at the Tempe Lab indicates that one of the major conflicts in Southwestern riparian zones is wildlife - livestock interactions.

Cattle, the most common livestock in the Southwest, prefer riparian zones for a variety of reasons. For instance, the quantity and quality of forage is higher and more palatable in riparian zones than adjacent upland forage. And cattle prefer to browse young tree seedlings such as cottonwood, ash, and willow, which are common in riparian ecosystems. Cool and shady, riparian zones also offer cattle protection from the scorching sun and dry desert wind.

But, wildlife managers frequently claim that overgrazing by livestock tends to disrupt and even destroy riparian vegetation, thereby reducing wildlife habitat. Studies show that although short-term fencing-off of riparian areas doesn't change plant species composition much between grazed and ungrazed areas, seedling reproduction and herbaceous understory increase on ungrazed areas. Szaro says the lack of seedling reproduction is one of the major factors causing the decline of Southwestern riparian zones.

To get a better understanding of wildlife-livestock interactions in riparian zones, scientists are using a time lapse movie technique to study methods of manipulating livestock grazing to increase forage quantity and quality for wildlife, and to decrease grazing effects on seedling reproduction. By associating wildlife species and livestock to different vegetation types, scientists will provide land managers with management guidelines. Diversity and indicator species may also be useful to land managers as an index to habitat quality and allow them to manage groups of species with common requirements.

Another research application important to land managers is a new method for censusing bird populations called the "variable circular-plot method." Szaro says, "Accurately estimating bird populations has been a major concern to biologists for years. Common censusing methods, such as spot-mapping and transects, present problems when applied to small, island-like areas with hetereogeneous vegetation. Spot-mapping is limited to breeding seasons when birds defend territories, while riparian islands are too small and variable for transects. This new censusing method is not limited to breeding seasons, and is applicable to small habitat islands."

Research needs for management

In addition to the comprehensive plant - animal classification system, land managers need information on the life histories of plant and animal species, and the influence of human activity on riparian zones, to develop management guidelines.

According to Szaro, life history information provides biological data useful in understanding each species role in the ecosystem. In the past, researchers have neglected the life histories and habitat needs of non-game birds, reptiles, amphibians, and mammals such as bats, squirrels, and skunks in favor of more economically important species. However, scientists now recognize the importance of all wildlife, including threatened and endangered species, in the food chain and in managing entire ecosystems. In addition, life histories on important riparian tree species — sycamore, cottonwood, willow, ash, and walnut — are almost non-existent. Studies on germination and sprouting of seedlings, effects of fire and insects, and techniques for artificial regeneration are needed.

Human influences on Southwestern riparian ecosystems are probably in need of the most research. Grazing, pollution, recreation, flooding, and water reclamation projects all impact riparian zones.

Land managers need to know recovery rates of ecosystems with different amounts and types of pollutants, and their chemical toxicity to plant - animal associations. Managers also need information on the carrying capacity of riparian ecosystems to regulate recreational, homebuilding, and other human uses. Data on minimum water flows and tables will enable land managers and property owners to maintain riparian habitat as a vital biological resource while mitigating losses from dam and reservoir projects.

An understanding of the various uses and their impacts on riparian ecosystems should provide land managers a means for evaluating alternative management decisions. Szaro says, "Management objectives should seek a balance between multiple use and perpetuation of the riparian ecosystem."

Flooding may either damage a riparian zone or create new seed beds. Here, winter flooding exposes roots of a cottonwood.

Research on the desert

by Tom Baugh
Intermountain Station

The Great Basin is a vast interior region of the United States bordered on the west by the majestic Sierra Nevada and the southern Cascade Mountain ranges and on the east by the precipitous Wasatch Range and the west face of the Colorado Plateau. This immense area includes all of Nevada, the western third of Utah, parts of eastern California, southeastern Oregon and southern Idaho.

The Great Basin is generally characterized as arid. This is, however, a land of amazing contrasts including areas such as Utah's Great Salt Desert, productive wetlands such as the Ruby Marshes, and rolling shrublands. Throughout the region numerous mountain ranges rise like islands from surrounding seas.

Most Great Basin rangeland is grazed by livestock—this industry is vital to the rural economies of this area. For example, federal ranges provide 30 percent of the livestock feed requirement in Utah and 45 percent in Nevada. Rangelands and the associated waters provide habitat for thousands of big-game animals and countless other wildlife including songbirds, upland game birds, waterfowl, and fish. These wildlife resources provide hunting and fishing opportunities and many other nonconsumptive values. Demands on the rangeland resources for recreation also increase with each passing year.

It is important that these rangelands be managed to maintain or improve all range resources. During the latter 1970's, however, it was estimated that much of the Great Basin rangeland was only producing half of its potential livestock forage, wildlife habitat, and protective watershed cover.

Scattered throughout the Great Basin are thousands of hectares of salt desert. These areas are characterized by minimal precipitation. Vegetation is limited to those hardy species which can survive low moisture and highly varying temperatures. Temperatures can range as much as 28° C during one day.

Desert experimental range

The Desert Experimental Range is located about 75 km (47 miles) west

Sheep are grazed and studied on the Desert Experiment Range.

of Milford, Utah. This 22,000 hectare area represents much of the lower elevation land throughout the Great Basin. About 75 percent of the Experimental Range is alluvial slope or flat valley bottom. The rest is steeper rockland overlain by a shallow soil mantle and broken by ledges of hard Paleozoic sedimentary or Tertiary volcanic rock. Elevations range from 1,547 to 2,565 meters. Soil textures are typically loams, sandy loams, or loamy sands.

The ground is frozen most of the time from mid-November into March. Snowfalls are usually light, seldom more than 5 cm deep. Snowfall of 25 cm or more may only occur 1 year out of 15 in early winter, but as often as 1 year out of 3 in late winter. The average annual precipitation is 157 mm, about half of which falls during the 5-month period from May through September.

The vegetation on the Experimental Range is a mosaic of low shrub and shrub-grass types. The different vegetational types reflect soil differences between sites. The dominant shrub species are winterfat, bud sagebrush, black sagebrush, shadscale saltbush, and little rabbitbrush. Three perennial grass species, Indian ricegrass, galleta, and sand dropseed are associated with shrubs on most soils.

Only one native ruminant, the pronghorn antelope inhabits the Desert Experimental Range. Jackrabbits and cottontail rabbits are found in or near the dry washes, on rocky slopes, and in canyons where taller shrubs provide concealment. Nine species of rodents are found throughout the area. Six species are mice and kangaroo rats, and three species are ground squirrels and pocket gophers. Predators include the coyote, kit fox, badger, weasel, two species of skunks, and an occasional mountain lion. Raptors are also common.

Research

Grazing studies began on the Desert Experimental Range during the winter of 1934-1935. Twenty large (129 ha) range pastures were each assigned a season or combination of seasons to be grazed by sheep at different stocking intensities. The rest of the area was divided into 14 units. Over the years, 11 have been grazed by sheep and two by cattle. One unit has not been grazed. It was from the studies on these plots that research has shown that proper resource management techniques have the ability to increase forage production by 45 percent.

Researchers have demonstrated the importance of season and intensity of grazing on salt desert shrub vegetation. Heavy grazing in late winter and early spring causes severe reduction of desirable perennial species which allows an invasion of undesirable plants in some years. This does not occur where proper management has maintained vigorous stands of desirable perennial species.

Long-term studies on the Desert Experimental Range have shown that the principal perennial species are long-lived and generally suffer little mortality after the second year of establishment. Winterfat, a small shrub species which is an important source of livestock forage, appears to have maintained a consistent presence in part because of this longevity. In 1975, over one-half of the plants present were at least 40 years old, and the individuals surviving that period continued to increase their size. Shadscale, on the other hand, has had a higher mortality rate and has had to depend on a higher reestablishment rate to maintain its status in the community. Its abundance has declined. Budsage has shown the most sensitivity to grazing of the three principal shrubs, but tends to replace shadscale when protected from grazing. Overall, however, there has been surprisingly few significant differences between the survival of plants in the ungrazed plots versus plots grazed during dormant periods.

In these communities of widely spaced perennials, much of the plant tissue is unseen. Only 14 percent of the mass of accumulated organic matter is above ground. The great majority occurs as roots in the unseen underground environment, although much of the underground nonliving organic materials apparently originated above ground and were worked under the soil surface by animal activity.

One of the more interesting finds which has been developed in part on the Desert Experimental Range relates to the role played by nonvascular plant communities in the protection of arid soils. These communities, which appear like a carpet over the soil, are known as cryptogamic crusts. Although the major component of the crust is algae, lichens and mosses may also be present. When the crust is intact it acts to preserve the soil from wind erosion. When the crust is disturbed, for example, by heavy grazing—especially during the summer—the underlying soil may become subject to erosion. It has been estimated that once a site is seriously disturbed and robbed of its cryptogamic crust, it could take 15 years before the crust becomes reestablished.

Many of the research programs on the Desert Experimental Range are cooperative efforts. For example, researchers of the Intermountain Forest and Range Experiment Station's Shrub Sciences Laboratory and the Utah Division of Wildlife Resources have recently completed studies that show antelope can flourish on valley bottoms, where they are not ordinarily found, if drinking water is made available for them. On many of these unoccupied areas the topography and forage are suitable but, unfortunately, the water is usually not present. The development of additional watering places helps increase potential antelope range.

Researchers hypothesize that making more water sites available during fawning season helps distribute the antelope population and may lessen the number of fawns killed by predators.

Antelope are the only native ruminant on the Desert Experimental Range.

Forage must also be available to sustain antelope. Studies have shown that the preferred winter forage on the Desert Experimental Range is black sagebrush. Antelope will also feed on grass for a short period in early spring while the growth is new. The production of forbs, which are preferred summer forage, is variable from year to year depending on the amount and time of summer rainfall. Research has demonstrated that succulence is the most important aspect of the feed antelope prefer. When forage is succulent, antelope do not drink water. In dry summers, however, they drink almost 3 liters per day.

The future

Although there have been significant gains in knowledge and techniques, much remains to be done.

The Intermountain Forest and Range Experiment Station is involved in a comprehensive range research and application program. Part of this program includes the Desert Experimental Range. The mission of the program is to increase the capabilities of land managers to maintain and improve the quality and productivity of Great Basin rangelands.

The program is composed of three parts:

1. To accelerate information dissemination and application of present technology;

2. To establish field tests, based on available knowledge, to demonstrate and evaluate the overall effectiveness of management prescriptions; and

3. To accelerate the research needed to enhance and protect range resource uses and values.

Because of the land management and ownership patterns in the Great Basin, it is important to note that the range research and application program is a cooperative effort of Federal, State, and local agencies and of the private sector.

Access to research

For additional information concerning the Desert Experimental Range contact one of the following:

Intermountain Forest and Range
Experiment Station
507 25th Street
Ogden, UT 84401

Intermountain Forest and Range
Experiment Station
Shrub Sciences Laboratory
735 N. 500 E.
Provo, UT 84601

For further reading, the following publications are available from the Intermountain Station:

Holmgren, Ralph C., and Sam F. Brewster, Jr. 1972. *Distribution of Organic Matter Reserve in a Desert Shrub Community.* USDA For. Serv. Res. Pap. INT-130, 15 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Holmgren, Ralph C., and Selar S. Hutchings. 1972. *Salt Desert Shrub Response to Grazing Use. In* Wildland Shrubs - Their Biology and Utilization, *Proc. Int. Symp.* p. 153-164. USDA For. Serv. Gen. Tech. Rep. INT-1. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Hutchings, Selar S. and George Stewart. 1953. *Increasing Forage Yields and Sheep Production on Intermountain Winter Ranges.* U.S. Dep. Agric. Circ. 925, 63 p. Washington, D.C.

Stewart, George, W. P. Cottom, and Selar S. Hutchings. 1940. *Influence of Northern Salt Desert Plant Associations in Western Utah.* J. Agric. Res. 60:289-316.

New Publications

To Order Publications

Single copies of publications referred to in this magazine are available without charge from the issuing station unless another source is indicated. When requesting a publication, give author, title and number.

Understanding dwarf mistletoe

Dwarf mistletoes are parasitic plants that rob conifers of nutrients and water, causing a decline in tree vigor. They are a problem in the western United States, where they stunt and kill western larch, ponderosa pine, lodgepole pine, Douglas-fir, western hemlock, mountain hemlock, and true firs. In 1978, 41 percent of the stands east of the Cascades and 10 percent of those west of the Cascades in Oregon and Washington were infected. Over a 10-year period infected Douglas-fir in the Okanogan National Forest had 10 percent more mortality than trees not infected. Volume losses as high as 37 percent have been found in western hemlock.

A new publication from the Pacific Northwest Station summarizes essential biological knowledge about dwarf mistletoes and answers questions about managing infected stands. The paper discusses the ways the six main species of mistletoe are spread through trees and stands and their effects on growth and mortality of trees. The amount growth is reduced depends on interacting factors that include the extent of infection, location within tree crowns, length of time present, age of trees, and stand density. After a decline in growth and vigor, trees eventually die of root rots or bark beetles.

Since mistletoes grow on nutrients and water stolen from trees, it is important to select management practices that favor growth of trees without indirectly increasing mistletoe growth. Recommendations for doing this are provided in *Dwarf Mistletoe and Host Tree Interactions in Managed Forests of the Pacific Northwest* by Donald M. Knutson and Robert Tinnin, General Technical Report PNW-111. Copies are available from the Pacific Northwest Station.

Evaluating slash fuel hazards

Commercial timber harvesting often leaves large quantities of combustible residues on the forest floor. This residue, also known as slash or activity fuel, increases fire hazard, hinders stand management, disrupts wildlife and livestock grazing, chokes stream channels, and degrades the site's aesthetic quality.

However, scientists now say slash creates many positive effects as well. Slash often produces a favorable micro-climate for seedling regeneration, provides habitat for certain wildlife species, returns nutrients to the soil, and in some cases reduces soil erosion.

A new publication by the Rocky Mountain Station, *The Activity Fuel Appraisal Process: Instructions and Examples*, General Technical Report RM-83 by Stanley N. Hirsch, David L. Radloff, Walter C. Schopfer, Marvin L. Wolfe, and Richard F. Yancik presents a strategy to systematically evaluate alternative slash management practices.

Based on quantitative modeling and decision theory, the appraisal process allows land managers to objectively correlate fuel quantities, adjacent fuel conditions, expected fire occurrence, climate, topography, fire suppression capability, and treatment costs. In the past, these factors were subjectively analyzed, sometimes producing wide variation in treatment for similar situations.

For a complete analysis of residue and fuel management needs, land managers must add to the "Fuel Appraisal Process" other treatment costs and benefits — wildlife habitat impact, erosion control, aesthetic enhancement, and regeneration improvement.

While the "Fuel Appraisal Process" does not provide the bottom line in analyzing the economics of alternative slash fuel treatments, it does provide needed fire hazard inputs.

If you would like more information write the Rocky Mountain Station and request the publication mentioned.

Effects of surface mining

As the Nation searches within its own boundaries for new sources of minerals, reclamation of surface mined areas is a primary concern to many land managers. A new publication issued by the Intermountain Station can help alleviate that concern.

The publication, *Environmental Effects of Surface Mining of Minerals Other Than Coal,* General Technical Report INT-95-FR27, is an annotated bibliography and report on the state of the art of lessening adverse effects of such mining. It was collected from various sources including computerized data bases, personal literature collections, and the results of a national survey. Compilers are Bland Z. Richardson, research forester, and Marilyn Marshall Pratt, lead technician, both located at the Intermountain Station's Forestry Sciences Laboratory in Logan, Utah.

To obtain as much current information as possible, Richardson and Pratt sent inquiries to some 340 knowledgable people. They asked for comments based on professional experience and research on environmental problems related to surface mining and for citations, publications, and reports on current research. Inquiries were sent to mining associations; to people presently conducting research on reclamation of surface mines; to environmental concern groups; and to all States' departments or divisions involved in reclamation of surface mines. The respondents' citations were cataloged and their comments recorded.

The annotated bibliography lists nearly 800 citations grouped by general problem subjects, including effects on water, land use planning and public policy, effects on vegetation, and economic and legal aspects.

The publication includes a cross-reference index of environmental effects of surface mining. For example, it lists citations that describe specific problems and the citations that describe solutions to those problems.

Richardson says the bibliography will be maintained as an active computerized file, and supplements will be published from time to time.

Copies of this comprehensive bibliography are available from the Intermountain Station.

What causes wetwood?

Wetwood is the heartwood of a tree filled with fluid produced by a disruption in the tree's physiological processes. It differs from normal heartwood in physical and chemical properties. It smells bad. It requires more time and energy to dry. And lumber and wood products produced from wetwood are more likely to develop ring failure and other defects.

The cause of wetwood is not known, and little research has been done to find out. It is thought that a combination of factors may initiate disruption of physiological processes that result in wetwood. Bacteria have been found in wetwood, but it is not known whether they are the cause or a result of the condition. There is substantial evidence that tree injuries are implicated.

Wetwood is found in both conifers and hardwoods. It is generally prevalent in hemlocks, true firs, poplar, and aspen. It occurs in many other species to varying degrees. Douglas-fir is one of the few species that are seldom affected. Trees with frost cracks and scars and knots with watery exudate show symptoms of wetwood. They will produce less utilizable wood than trees without these symptoms, and the wood will take from 2 to 4 times more energy to dry. The condition does not improve; it can only get worse and increase processing problems.

A new publication from the Pacific Northwest Station pulls together what is known about wetwood and recommends a program of multidisciplinary research to find its cause and ways to control or prevent it.

Copies of *Wetwood in Trees: A Timber Resource Problem* by J. C. Ward and W. Y. Pong, General Technical Report PNW-112, are available from the Pacific Northwest Station.

Growing wildland shrubs

Many disturbed sites in the West can be reclaimed by topsoiling, irrigation, and other measures, but the bottom line is that it is often prohibitively expensive. One alternative is to establish vigorous self-sustaining conditions similar to native ecosystems. This alternative, however, means that reclamation specialists need information on a wide variety of native and domestic plants in a wide variety of environments.

A report issued by the Intermountain Station contains information on wildland shrubs that should be valuable to the reclamation specialists. Kimery C. Vories, engineer in charge of environmental programs for two mines in Missouri, compiles existing germination and plant propagation information for people planting native or naturalized Colorado shrubs. Although the emphasis is on plants in Colorado, many of the species are also found in the Intermountain and Rocky Mountain regions, as well as in parts of the Pacific Northwest.

The report includes information on the seed procurement, pretreatment, laboratory germination, and culture of 127 Colorado shrub species. It also contains 234 literature citations, a list of the Colorado shrub species that have been evaluated by USDA Soil Conservation Plant Materials Centers, and the addresses of plant materials centers in the western United States. In addition, the report lists the commercial suppliers of Colorado shrub seed, seedlings, and transplants, and the addresses of commerical suppliers of Colorado shrubs.

Copies of *Growing Colorado Plants from Seed: A State of the Art*, General Technical Report INT-103-FR27, are available from the Intermountain Station.

A common language for fire behavior

Research publications on fire effects and discussions among investigators reveal a serious problem: seldom is a subject fire described in measurable terms. Two Forest Service scientists have proposed a way to correct the problem—standardized methods to describe fire behavior.

Dick Rothermel, project leader of the Intermountain Station's research work unit concerned with fire behavior, and John Deeming, research forester with the Pacific Northwest Station, discuss these methods in a report issued by the Intermountain Station.

Rothermel and Deeming say that, as a consequence of using nonstandard qualitative descriptors, knowledge of fire behavior and fire's effects is of limited value because it is very difficult, if not impossible, to correlate and communicate results of different studies.

The scientists have selected fire characteristics that are intuitively related to certain fire effects, and show ways to derive those characteristics from simple field observations. The descriptions are written for scientists not usually involved in fire studies, who will be designing and conducting experiments, and for fire researchers who need a system for predicting fire effects.

Write to the Intermountain Station for a copy of *Measuring and Interpreting Fire Behavior for Correlation with Fire Effects*, General Technical Report INT-93-FR27.

Producing plywood and particleboard from Black Hills ponderosa pine

Wood product manufacturers in Wyoming and South Dakota may have new opportunities to utilize ponderosa pine timber and residues from wood processing operations in the Black Hills.

Information on the feasibility of producing plywood and particleboard in Wyoming and South Dakota is available in two publications from the Rocky Mountain Station: *Potential for Producing Ponderosa Pine Plywood in the Black Hills*, Resource Bulletin RM-4, by Dennis M. Donnelly and Harold E. Worth; and *Economic Potentials for Particleboard Production in the Black Hills*, Resource Bulletin RM-5 by Donald G. Markstrom and Harold E. Worth. The Resource Bulletins are a new series of publications by the Rocky Mountain Station devoted to economic studies of natural resources.

The available supply of ponderosa pine saw timber and, particularly, a substantial volume of processing residues are not fully utilized at present. Economically and environmentally, plywood and particleboard production may offer attractive alternatives for utilizing the sawtimber surplus and mill residues.

Scientists and economists estimate the supply of ponderosa pine timber in the Black Hills meeting the required size and quality for plywood, is adequate to serve both the present lumber industry and a new plywood plant, at least until 1986. However, after 1986, sawtimber supplies may not be sufficient to support both industries if the existing lumber industry regains former production levels.

Interest in particleboard production stems from several factors — left-over residues from primary and secondary wood processing operations; tightened burning restrictions making disposal of excess residues difficult; compatibility with existing Black Hills industries; and outlets for an excess of small roundwood, removal of which improves forest quality and management.

The north central U. S. would probably be the prime market for Black Hills plywood and particleboard. Not only is there a great demand for these wood products in this area, but Black Hills producers also have lower rail and truck freight costs to that area than western and southern producing regions.

Studies show the five principal market categories for plywood include residential and nonresidential construction, industrial, distribution (i.e., repair and remodeling), and miscellaneous (international, government, and military markets).

Economists have divided markets for particleboard into two groups: construction and industrial, with a higher proportion being used by industry.

For more information, write the Rocky Mountain Station and request the publications mentioned earlier.

Controlling tree diseases in the Great Plains

Pines and junipers are widely used in the Great Plains for a variety of purposes — protection of soil, crops, wildlife, livestock, and homesteads, wildlife habitat, landscaping, and windbreaks.

A recent publication, *Pine and Juniper Diseases in the Great Plains,* General Technical Report RM-86, by Glenn W. Peterson, plant pathologist at the Rocky Mountain Station's Lincoln, Nebraska lab, summarizes research on five diseases of pines and three diseases of junipers.

Great Plains land managers, property owners, and others should find this publication useful because it emphasizes identification, control, and geographic distribution of diseases. In addition, physiological and morphological information on pathogens is included for researchers working with pathogens in labs.

If you would like a copy of *Pine and Juniper Diseases in the Great Plains,* write the Rocky Mountain Station.

Prescribed burning reviewed in report

Prescribed burning—the use of fire under carefully prescribed weather and fuel conditions—is "a wildland management tool whose time has come," according to Range Scientist Lisle R. Green of the Pacific Southwest Station's Forest Fire Laboratory in Riverside, California. Green has briefly summarized the results of more than 20 years of research and experience with prescribed fire in his new publication, *Burning by Prescription in Chaparral,* General Technical Report PSW-51. Although his emphasis is on the use of prescribed fire in California's 20 million acres of chaparral ecosystems, the information in the Report is also applicable to other Western States as well, where such chaparral species as manzanita, scrub oak, and ceanothus occur.

Green reviews what he regards as "the main concerns of the prescribed burn manager," including the procedures necessary to plan, carry out, and evaluate a prescribed burn. The recommendations that he presents are designed "to guide decisionmaking at each step of the prescribed burn procedure."

This procedure "begins long before the fire is lit, and does not end until long after the fire is out," he says. Perhaps the most time-consuming step is preparing the burn plan, which should be a statement of the objectives of the prescribed burn, the location and estimated size of the fire, the target date, the proposed ignition technique, and the manpower and equipment needed. Green explains how to write the prescription, how to conduct a test burn, and how to follow with the prescribed burn and post-fire appraisal. Included in his discussion is information on fuel moisture, fuel volume, and the influence of topography, time of day, season, weather, and the chemical content of the plants. He also talks about smoke management, and describes the Federal and State of California air quality regulations that apply to forest or brushland burns.

Green says his purpose in preparing the Report was to "reinforce the increased emphasis on prescribed burning as an effective technique for reducing the hazardous accumulation of natural fuels, for improving wildlife habitat, or for increasing water yield." He also points to the successful use of prescribed burning "to reduce undesirable plants, prepare a site for planting of trees or seeding of perennial grasses, or improve ease of access into brush."

Copies of the Report are available from the Publications Distribution Section, Pacific Southwest Station.

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Mountain pine beetles and lodgepole pine—A compatible relationship

The mountain pine beetle has killed millions of trees in the United States and Canada. During epidemics, one National Forest may lose more than a million trees in a single year. But the mountain pine beetle and lodgepole pine have evolved into an intensive and highly compatible relationship. Consequently, stand dynamics of lodgepole pine is a primary factor in the development of beetle epidemics.

Research focusing on the population dynamics of the mountain pine beetle in lodgepole pine forests is carried out by researchers of the Intermountain Station. Project Leader Walter Cole and Principal Entomologist Gene Amman have documented a phase of their efforts in *Mountain Pine Beetle Dynamics in Lodgepole Pine Forests, Part I: Course of an Infestation,* General Technical Report INT-89-FR27.

In the report, the scientists discuss how the beetle "moves through" the stand, with emphasis on relationships between the beetle and its environmental factors.

The paper represents much original research by Cole and Amman, but it is also a review of other published literature about the mountain pine beetle, with particular reference to epidemic infestations.

Write to the Intermountain Station for copies.

Aerial photos help rate risk of tussock moth defoliation

Forest managers can use aerial photographs to determine which stands are most likely to be defoliated by the Douglas-fir tussock moth. A new publication from the Pacific Northwest tells how. The process involves measuring factors that affect the susceptibility of stands to tussock moth defoliation and assigning the stands to five classes of risk based on these measurements.

Variables that affect the susceptibility of stands to tussock moth defoliation—aspect, slope, elevation, topographic location, radiation index, stand purity, and crown diameter and density—can be measured by someone skilled in photo interpretation. Instructions for interpreting variables, a list of equipment needed, templates, and regression equations are provided.

The equations that rate the risk of defoliation were developed from data collected in the Blue Mountains of eastern Oregon and Washington and are generally applicable to those areas. Slightly modified models have also been used successfully in northern Idaho and can probably be applied elsewhere—especially if supplementary stand data is available.

Copies of *Rating the Risk of Tussock Moth Defoliation Using Aerial Photographs* by Robert C. Heller and Steven A. Sader, Agricultural Handbook No. 569, are available from the Pacific Northwest Station.

Watch for the next issue of Forestry Research West. You'll read about a new ecological classification system for southwestern forests; how scientists are finding better ways for managing Sierra Nevada coniferous forests; review several new research publications; plus more.

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